

MERRIMACK RIVER BASIN
GREENVILLE; NEW HAMPSHIRE

OTIS COMPANY DAM NO. 1

NH 00041

NHWRB 101.01

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

MARCH 1979

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ABSTRACT (Continue on reverse side if necessary and identify by block number) The dam is a concrete faced stone masonry gravity dam with an overall length of 150 ft. and a maximum height of 27 ft. It is small in size with a significant hazard potential. The dam is in fair condition at present time, requiring some remedial work to the structure.		



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

REPLY TO
ATTENTION OF:
NEDED

JUN 25 1979

Honorable Hugh J. Gallen
Governor of the State of New Hampshire
State House
Concord, New Hampshire 03301

Dear Governor Gallen:

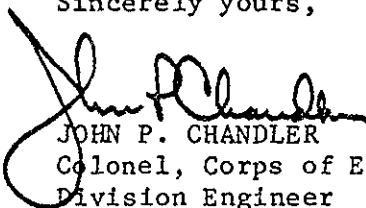
I am forwarding to you a copy of the Otis Company Dam No. 1 Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. A brief assessment is included at the beginning of the report. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Water Resources Board, the cooperating agency for the State of New Hampshire. In addition, a copy of the report has also been furnished the owner, Pioneer Plastics, 160 Emerald Street, Keene, New Hampshire 03431.

Copies of this report will be made available to the public, upon request, by this office under the Freedom of Information Act. In the case of this report the release date will be thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Water Resources Board for your cooperation in carrying out this program.

Sincerely yours,


JOHN P. CHANDLER
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

OTIS COMPANY DAM NO. 1
NH 00041

MERRIMACK RIVER BASIN
GREENVILLE, NEW HAMPSHIRE

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

NATIONAL DAM INSPECTION PROGRAM

PHASE I REPORT

Identification No.: NH 00041
NHWRB No.: 101.01
Name of Dam: OTIS COMPANY DAM NO. 1
Town: Greenville
County and State: Hillsborough, New Hampshire
River: Souhegan River
Date of Inspection: November 14, 1978

BRIEF ASSESSMENT

Otis Company Dam No. 1 is a concrete-faced stone masonry gravity dam with an overall length of about 150 feet. The dam has a maximum height of 27 feet. The spillway is 94 feet long and 22 feet high. There are no operating outlet structures at the dam.

The dam, which lies on the Souhegan River in Greenville, N.H. was once used for power generation at the mill located on the left side of the dam. At present, the dam serves no readily identifiable purpose. The drainage area consists of 29.6 square miles of moderately to steeply sloping forested terrain. The dam's maximum impoundment of 105 acre-feet and height of 27 feet place the dam in the SMALL size category. In the event of a dam failure, the possibility of property damage but small chance of loss of life dictates that a SIGNIFICANT hazard potential classification be assigned for the dam.

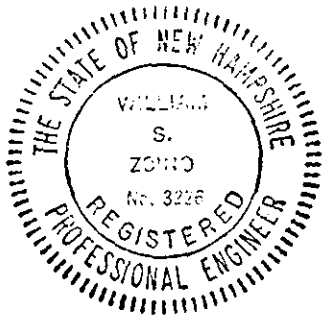
Based on the size and hazard classifications, and in accordance with the Corps' of Engineers guidelines, the Test Flood (TF) would be between the 100-year flood and one-half the Probable Maximum Flood (PMF). Since the hazard potential is on the low side of the SIGNIFICANT category, the Test Flood flow at Otis Company Dam No. 1 is taken as the 100-year flood.

The selected TF inflow of 5000 cfs is also taken as the flow at the dam because of the small storage available at the dam. The peak test discharge of 5000 cfs would result in a maximum stage of 6.2 feet above the spillway crest, or 0.2 feet above the concrete wall at the right abutment and 1.5 feet above the ground surface at the left abutment.

Otis Company Dam No. 1 is in FAIR condition at the present time, requiring some remedial work to the structure. In particular, it is recommended that the former forebay inlets

and sluice gates be investigated by a qualified engineer and that appropriate measures be taken based on those findings. Recommended remedial measures include monitoring of the seepage at the left spillway end wall, chinking of the voids in the downstream face of the spillway, instituting a program of annual technical inspections, and developing a formal warning system to alert downstream people in case of emergency.

The recommendations and improvements outlined above should be implemented within one year of receipt of this report by the owner.



William S. Zoino
William S. Zoino
New Hampshire Registration 3226



Nicholas A. Campagna, Jr.
Nicholas A. Campagna, Jr.
California Registration 21006

This Phase I Inspection Report on Otis Company Dam No. 1 has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.

Joseph A. McElroy

JOSEPH A. MCELROY, MEMBER
Foundation & Materials Branch
Engineering Division

Carney M. Terzian

CARNEY M. TERZIAN, MEMBER
Design Branch
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Joseph W. Finegan, Jr.

JOSEPH W. FINEGAN, JR., CHAIRMAN
Chief, Reservoir Control Center
Water Control Branch
Engineering Division

APPROVAL RECOMMENDED:

Joe B. Fryar

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Test Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the Test Flood should not be interpreted as necessarily posing a highly inadequate condition. The Test Flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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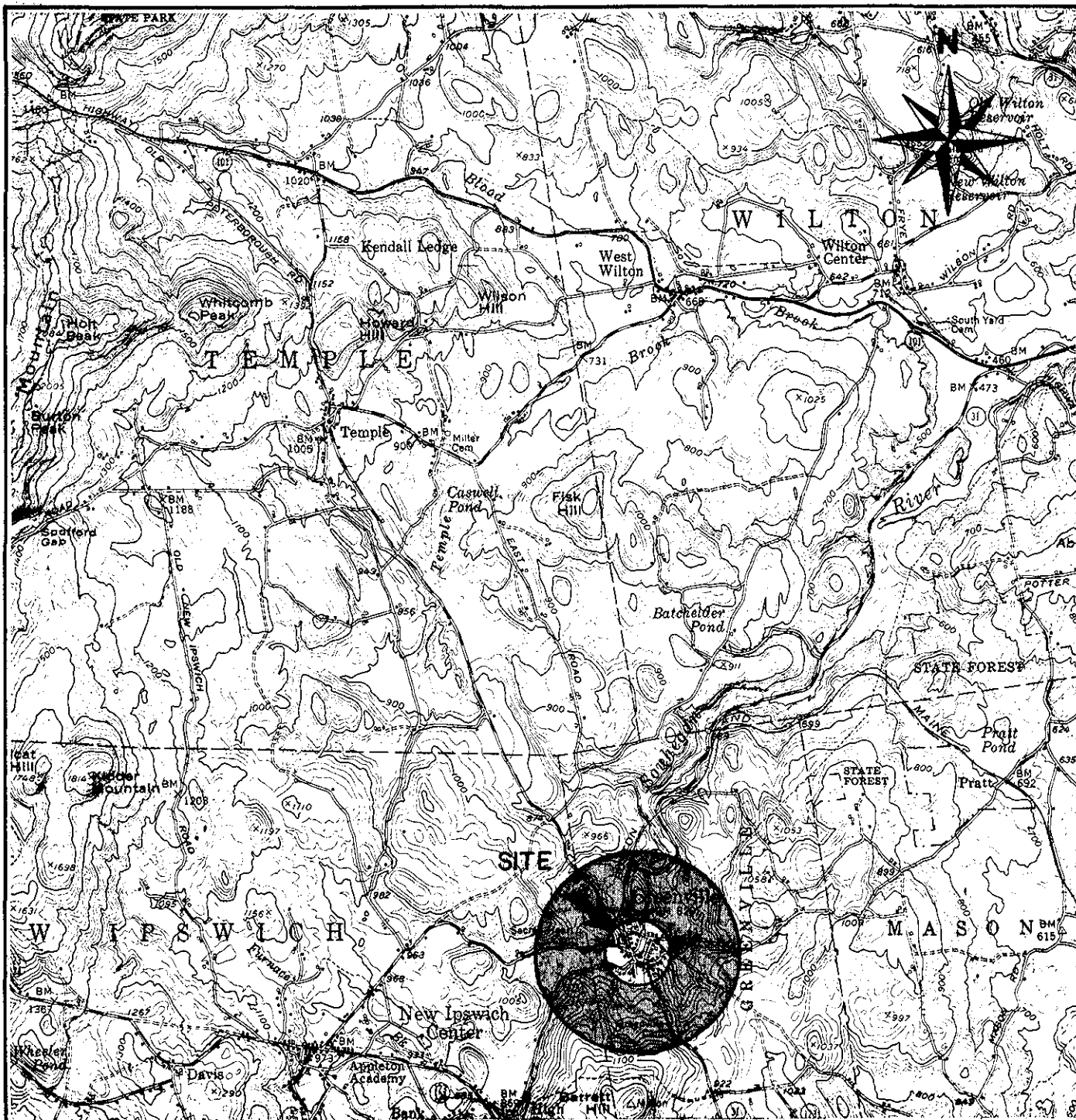
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Overview from road bridge downstream
of dam



Overview from upstream left side
of dam



— SCALE —
0 1/2 2 MILES

FROM: USGS PETERBOROUGH, N.H.
QUADRANGLE MAP

GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC.
GEOTECHNICAL CONSULTANTS
NEWTON UPPER FALLS, MASS.

U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOCUS PLAN

FILE No. 2201

OTIS COMPANY DAM No. 1

NEW HAMPSHIRE

SCALE AS NOTED

DATE JANUARY 1979

PHASE I INSPECTION REPORT

OTIS COMPANY DAM NO. 1

SECTION 1

PROJECT INFORMATION

1.1 General

(a) Authority

Public Law 92-367, August 8, 1972, authorized the secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Goldberg, Zoino, Dunncliff & Associates, Inc. (GZD) has been retained by the New England Division to inspect and report on selected dams in the State of New Hampshire. Authorization and notice to proceed was issued to GZD under a letter of November 28, 1978 from Colonel Max. B. Scheider, Corps of Engineers. Contract No. DACW 33-79-C-0013 has been assigned by the Corps of Engineers for this work.

(b) Purpose

(1) Perform technical inspection and evaluation of non-federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-federal interests.

(2) Encourage and prepare the states to initiate quickly effective dam safety programs for non-federal dams.

(3) Update, verify, and complete the National Inventory of Dams.

(c) Scope

The program provides for the inspection of non-federal dams in the high hazard potential category based upon location of the dams and those dams in the significant hazard potential category believed to represent an immediate danger based on condition of the dam.

1.2 Description of Project

(a) Location

Otis Company Dam No. 1 lies on the Souhegan River in Greenville, New Hampshire. The dam lies approximately 170 feet upstream from the bridge that carries N.H. Route 31 over the Souhegan River in Greenville. The portion of USGS Peterborough, N.H. quadrangle presented previously shows this locus. Figure 1 of Appendix B presents a detail of the site developed from the inspection visit and the quadrangle map.

(b) Description of Dam and Appurtenances

The dam is approximately 150 feet long and 27 feet high and consists of a stone masonry gravity spillway, a forebay structure on the left bank with an upstream end wall, a series of concrete and stone training walls upstream of the right end of the spillway, and stone and concrete training walls downstream of the spillway. A mill building is located immediately downstream of the forebay structure and the left end of the spillway. The right side of the mill building foundation serves as an intermediate training wall. An old intake structure is located on the right upstream bank.

The top of the left spillway training walls and the left forebay wall are approximately 3.7 feet above spillway crest elevation. The right spillway wall and upstream training walls are approximately 6 to 8 feet above spillway crest elevation. The spillway, the spillway end walls, the left spillway training walls, and the downstream training walls are all founded on bedrock. The foundation material for the left upstream end wall could not be determined. Figure 2 of Appendix B presents a detailed plan of the layout of the dam.

(c) Size Classification

The dam's maximum impoundment of 105 acre-feet and height of 27 feet are below the 1000 acre-foot and 40 foot height limits for the SMALL size category as defined in the "Recommended Guidelines."

(d) Hazard Potential Classification

In the event of a dam failure, the only structures expected to be affected by the flood wave would be some homes located on the right bank about 2500 feet downstream from the dam. The flood wave would be expected to reach a height of about 1 foot above the sill level of the houses, thereby causing serious economic loss but not posing a significant threat of loss of life. For these reasons a SIGNIFICANT hazard potential classification is warranted.

(e) Ownership

The dam is owned by Pioneer Plastics of Greenville, N.H. Mr. William Blease oversees the dam and can be reached by telephone at 603-878-2774 or 603-357-0359. The address for Pioneer Plastics is 160 Emerald Street, Keene, N.H., 03431.

(f) Operator

No operation is performed at the dam.

(g) Purpose of Dam

The dam was originally constructed to provide a supply of water for power generation to the mill building on the left downstream side of the dam. At the present time no power is being generated.

(h) Design and Construction History

The dam was originally constructed in 1834 probably to provide power for the mill located on the left downstream side. After the 1936 flood repairs were made to the spillway crest, which had been damaged. The repairs consisted of replacing a former timber spillway with a concrete cap and constructing the right concrete spillway end wall and training wall.

(i) Normal Operating Procedure

No operation of the dam is performed.

1.3 Pertinent Data

(a) Drainage Area

Otis Company Dam No. 1 receives runoff from 29.6 square miles of moderately to steeply sloping forested terrain. Only a small portion of the drainage area is developed. Some developed properties are located on the right upstream side of the dam. Several old mill buildings are located next to the downstream channel in Greenville.

(b) Discharge at Damsite

(1) Outlet Works

The only identifiable outlet works for the structure are the two inlet openings in the forebay area and an intake sluice gate on the right upstream bank. None of these outlet works are presently operable.

(2) Maximum Known Flood at Damsite

The peak discharge reported for the damsite in U.S. Geological Survey Water Supply Paper No. 798 was 6160 cfs in March 1936.

(3) Spillway Capacity at Maximum Pool Elevation:

3100 cfs at elevation 830.1

(c) Elevation (feet above MSL)

- (1) Top of dam: 830.1
- (2) Maximum pool: 830.1
- (3) Normal pool: 825.4
- (4) Spillway crest: 825.4
- (5) Streambed: 803.5 ±
- (6) Maximum tailwater: Unknown

(d) Reservoir

- (1) Length - maximum pool: 2600 feet \pm
normal pool: 2200 feet \pm
- (2) Storage - maximum pool: 105 acre-feet \pm
normal pool: 75 acre-feet \pm
- (3) Surface area - maximum: 8 acres \pm
normal: 7 acres \pm

(e) Dam

- (1) Type: Stone masonry gravity on bedrock
- (2) Length: 150 feet \pm
- (3) Height: 27 feet \pm
- (4) Top width: 3 feet \pm at spillway
- (5) Side slopes: U/S at spillway - approx. 1 horizontal
to 1 vertical
D/S at spillway - vertical

(f) Spillway

- (1) Type: Stone masonry gravity
- (2) Length of weir: 93.8 feet
- (3) Crest elevation: 825.4
- (4) U/S channel: Broad approach from pond
- (5) D/S channel: Approx. 90 feet wide with
rocky bottom. Mill building and
stone walls confine the channel

(g) Regulating Outlets - See Section 1.3 (b) (1)

SECTION 2 - ENGINEERING DATA

2.1 Design Records

The design of this dam is quite simple and incorporates no unusual features. No original design drawings or calculations are available.

2.2 Construction Records

No construction records are available for this dam.

2.3 Operational Records

There are no operational records available for the dam.

2.4 Evaluation

(a) Availability

The absence of design drawings and calculations is a significant shortcoming. An overall unsatisfactory assessment for availability is therefore warranted.

(b) Adequacy

The lack of in-depth engineering data does not permit a definitive review. Therefore, the adequacy of the dam cannot be assessed from the standpoint of reviewing design and construction data. This assessment is based primarily on visual inspection, past performance, and sound engineering judgment.

(e) Validity

Since the observations of the inspection team generally confirm the information contained in the files of the New Hampshire Water Resources Board, a satisfactory evaluation for validity is indicated.

SECTION 3 - VISUAL OBSERVATIONS

3.1 Findings

(a) General

Otis Company Dam No. 1 is in FAIR condition at the present time. Some remedial and maintenance type repairs would improve the condition of the dam.

(b) Dam (Refer to Figure 2 in Appendix B)

(1) Left Upstream End Wall

The cemented stone masonry wall, abutting the forebay, is in fair condition. It does not show any evidence of displaced stones, bulging, settlement, or erosion of mortared joints. The upstream, dry stone masonry section of the wall has settled, and several face stones are displaced. Rusted flashboard stanchions are set on top of this wall. A four foot high chain link fence is located adjacent to the top of the cement stone wall. A three foot high chain link fence abuts the remainder of the wall. The fence is in good condition.

(2) Forebay

This structure consists of cemented stone masonry training walls. The wall on the left bank is in fair condition. The right wall has partially unravelled and is tilting outward into the forebay entrance. Riprap has been placed in the forebay entrance in front of this wall. Apparently, this wall is undermined. Observations revealed that the framing members of the timber service platform are rotted at numerous locations. The timber trash rack is slightly rotted. The steel trash rack is very corroded.

The two inlet gates consist of bench stands with an operating wheel. The operating wheel is rotated by inverting a crowbar in sockets on the wheel rim. These gates have not been operated in the recent past. The size and type of sluice gates could not be determined. These gates are connected to a penstock within the building foundation.

A 10-inch diameter cast iron pressure relief vent is located immediately upstream of the building. The vent is equidistant between the gate bench stands.

(3) Left Spillway End Wall

This structure is in fair condition, and, with the exception of erosion of mortared joints, it does not show any evidence of displacement or other signs of distress. The return wall to the forebay entrance consists of dry stone masonry capped with random stone mortared in place. At some time in the past the top of this wall unravelled and was reconstructed. It is in fair condition at the present time.

The downstream face of the end wall is in good condition with no evidence of displaced stones, bulges, or other signs of distress. The cut-off wall extension to the left bank is in good condition. Flashboard stanchion sockets are set in the top of this wall.

A concrete structure with an encased pipe is located immediately downstream of the end wall in line with the left end of the spillway. The pipe outlet consists of a permanently sealed 18-inch diameter butterfly valve. The operating equipment has been removed. The upstream inlet of this pipe could not be observed. The concrete structure is eroded from its base to a height of approximately 4 feet, a width of 2 feet, and a depth of up to 12 inches. Seepage flows out of this eroded area at the rate of approximately 2 gpm. A 6 inch diameter tree stump is located on the top surface of this concrete structure. A small amount of seepage was observed at the interface of the base of the end wall and the rock foundation.

(4) Spillway

Visual observations revealed that the concrete cap on this structure is severely eroded over its entire length. This erosion is attributed to cavitation and ice damage. The downstream face of the spillway, adjacent to the right spillway end wall, is eroded over a distance of approximately 8 feet, a depth of 18 inches, and a vertical height of 18 inches. The top of the spillway

at this point is eroded over its top 3 foot width, for a distance of 3 feet, and to a depth of 2 inches. This erosion is attributed to ice damage.

The downstream face of the spillway has open joints in the dry stone masonry. Many of these joints are in the range of 3 to 4 inches in width. Chinking stones have washed out of the face of the dam. The interface with the rock outcrop at the left end is eroded, and stones have been displaced.

(5) Right Spillway End Wall

The base of this structure is eroded for a length of 10 feet where it abuts the spillway. This erosion is approximately 2 feet in height and up to 12 inches deep. The base of this structure at the interface with the spillway crest is eroded in excess of 2 inches. The remaining portion of this structure is in good condition with no evidence of spalls, cracks, or efflorescence.

(6) Right Upstream Training Walls

The dry stone masonry wall, located between the right spillway end wall and the sluice gate structure, is in fair condition with no evidence of displaced stones, bulging, or other signs of distress.

The concrete portion of the building foundation is honeycombed over 50% of its vertical face. Erosion at the water line adjacent to the sluice gate inlet structure is approximately 6 inches high, 3 feet long, and up to 6 inches deep. This erosion is attributed to ice damage. The random dry stone masonry supporting this wall was not uniformly placed but does not show any evidence of distress. The cemented stone masonry wall cap, which supports the building's brick foundation, is in good condition.

The sluice gate structure is in poor condition. The concrete is eroded at crest level and is spalled on its vertical face. The erosion is attributed to ice damage, and the spalling is attributed to moisture intrusion which has been subjected to alternating freeze and thaw cycles.

The timber sluice gate consists of a single stem mounted rack gear driven by a spindle gear. The assembly was operated by a hand crank which has been removed. The timber stem is completely rotted, and this structure is no longer operable. The gated width is 2 feet, 7 inches. The depth of the gate could not be determined. Water levels on both sides of the gate were at the same elevation indicating that the gate is leaking. This leakage was observed in the tailrace openings at the base of the right downstream training wall. The wooden trash rack is partially rotted.

(7) Downstream Training Walls

The cemented stone masonry wall between the left spillway end wall and the building foundation is in good condition with no evidence of displaced stones, bulging, or other signs of distress.

The building foundation wall is in good condition with no evidence of distress. The intermediate buttress located on this wall is effloresced over one-third of the mortared joints.

The dry stone masonry wall, which has been placed in front of the building foundation wall downstream of the tailrace outlet, is in fair condition with no evidence of displaced stones, bulging, or other signs of distress.

The concrete tailrace outlet is spalled over 50% of its exposed faces. This spalling is attributed to moisture intrusion which has been subjected to alternating freeze and thaw cycles. The base of the structure is eroded from the channel invert for a vertical height of approximately 3 feet. This erosion is attributed to cavitation and ice damage. The timber flap gate has been completely destroyed. The condition of the tailrace outlet is not serious since it is no longer used.

The downstream concrete training wall, which terminates at the left bridge retaining wall, is honeycombed over 50% of its face. There is no evidence of spalls, cracks, or efflorescence on this wall. Two rows of 4 weep holes are located approximately 3 and 10 feet respectively below the top of this wall.

The right training walls, including its splayed sections are in good condition with no evidence of displaced stones, bulging, or other signs of distress. Three tailrace outlets penetrate through the base of this wall approximately 50 feet downstream of the spillway. These outlets are approximately 18 inches high and three feet wide. Water was observed flowing through these openings. It is presumed that the source of the seepage is the sluice gate structure on the upstream right bank. The wood picket fence on the top of this wall is in fair condition.

(8) Mill Building

The building, which is approximately 53 feet wide and 70 feet long, is in good condition with the exception of the basement floor which is partly rotted. A penstock, located in the basement, penetrates through the upstream training wall opposite the forebay opening. This penstock is connected to a turbine which is no longer in use. A power generator is also located in the building. The power generating equipment is no longer operational.

3.2 Evaluation

Otis Company Dam No. 1 is in FAIR condition at the present time. Of major concern is the condition of the seals for the two inlet structures in the forebay area and the seal for the sluice gate on the right side. Repair of deteriorated concrete needs to be undertaken for several structures, and chinking stones need to be placed in the spillway. Routine maintenance procedures for the dam need to be improved.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 Procedures

At present the dam is not operated. Water flows over the spillway in an uncontrolled manner.

4.2 Maintenance of Dam

There is no maintenance program for the dam, and no maintenance has been done since Pioneer Plastics acquired the dam.

4.3 Maintenance of Operating Facilities

There is no maintenance performed on any of the inlet or sluice gates. None of the gates are presently operable.

4.4 Description of Warning System

There is no formal warning system in effect for this dam.

4.5 Evaluation

The dam's present FAIR condition is largely a result of the lack of maintenance performed at the dam. The present maintenance and operating policy is not satisfactory for continued long-term use of the dam. A formal written warning system is recommended because of the possibility of damage to downstream structures in the event of a dam failure.

SECTION 5 - HYDRAULICS/HYDROLOGY

5.1 Evaluation of Features

(a) General

Otis Company Dam No. 1 is a run-of-the-river dam. It consists of a concrete capped stone masonry gravity structure with a 150 foot long spillway and a forebay structure and mill building at the left side of the spillway. The intake structure into the mill building is no longer operational. An intake structure on the right upstream bank is also not operational.

(b) Design Data

Data sources available for Otis Company Dam No. 1 include prior inventory and inspection reports. The New Hampshire Water Control Commission's "Data on Dams in New Hampshire" (Dec. 6, 1938); and the New Hampshire Water Resources Board's "Inventory of Dams and Water Power Developments" (October 29, 1937) provide much of the basic data for the dam. Inspection reports from June 26, 1930, June 27, 1951, and October 1, 1974; correspondence in 1936 from the dam's owners to the New Hampshire Public Service Commission concerning proposed minor repairs; and a series of Water Power Questionnaires are also available.

In addition, Anderson-Nichols and Company, Inc. (ANCO) provided copies of data, computations, and drawings performed for a Flood Insurance Study (FIS) which included the Souhegan River and Otis Company Dam No. 1. These included cross-section data and 10, 50, 100 and 500-year peak discharges at various points on the Souhegan River (including the dam) as well as a topographic map showing the Souhegan River as it passes through Greenville.

(c) Experience Data

Data on peak discharges at the Otis Company Dam is available in U.S. Geological Survey (USGS) Water Supply Papers 798 and 867, which report estimated peak discharges experienced during major storms in March, 1936, and September 1938. The 1936 estimated peak was 6160 cfs and the 1938 value was 4970 cfs.

The "Inventory of Dams and Water Power Developments" (referenced above) cites a New Hampshire Water Resources Board report indicating that the high water level resulting from the 1936 storm was 6.3 feet above the spillway crest with a peak discharge of 6200 cfs. This flood caused some injury to the dam necessitating repairs which were completed in that year.

A Water Control Commission questionnaire completed by the dam's owners indicates that the peak flood level for the 1938 storm was approximately 5 feet above the spillway crest.

(d) Visual Observations

Downstream from the dam, the Souhegan River channel is very steep and narrow with high banks. Immediately below the dam the foundation walls of the mill building line the left bank, and further downstream a number of mill buildings and residences have been built along the banks. There is a small spillway structure with crest elevation 804.6 about 300 feet downstream of Otis Company Dam No. 1. Another spillway structure is located about 500 feet further downstream. The river is crossed by bridges about 170 feet and 1000 feet downstream of Otis Company Dam No. 1. The first bridge has a lower chord elevation of 818.8 while the second has a high arch.

At a point about 2200 feet downstream of the dam, the stream channel begins a transition from a very steep channel with high banks to a relatively milder sloped one with low banks, allowing for fairly extensive over-bank flooding at high flow rates. There are several houses near the right bank with ground floor elevations approximately 6 feet above the streambed along a reach from about 2500 to about 3000 feet downstream of the dam. The Souhegan River then continues for about another mile with similar characteristics. No structures are located in the floodplain along this reach.

(e) Test Flood Analysis

The hydrologic conditions of interest in this Phase I investigation are those required to assess the dam's overtopping potential and its ability to safely allow an appropriately large flood to pass. This requires using the discharge and storage characteristics of the structure to evaluate the impact of an appropriately-sized Test Flood. None of the original hydraulic and hydrologic design records are available for use in this study.

Guidelines for establishing a recommended Test Flood based on the size and hazard classifications of a dam are specified in the "Recommended Guidelines" of the Corps of Engineers. The impoundment of less than 1000 acre feet and height of less than 40 feet classify this dam as a SMALL structure.

The hazard potential for the Otis Company Dam is considered to fall within the SIGNIFICANT category. This is based mainly on the possibility of some damaging flooding at several houses one half mile downstream. The possibility of significant economic damage, but low loss of life potential make the SIGNIFICANT classification appropriate.

As shown in Table 3 of the Corps of Engineers' "Recommended Guidelines," the appropriate Test Flood for a dam classified as SMALL in size with SIGNIFICANT hazard potential would be between the 100-year flood and one-half times the Probable Maximum Flood (PMF). Where a range of values is indicated for the Test Flood, the magnitude of the flood should be related to the hazard potential. Since the hazard is on the low side of the SIGNIFICANT category, the Test Flood flow at Otis Company Dam No. 1 is taken to be the 100-year flood.

Previous ANCO FIS study results provide estimated values for the 10, 50, 100 and 500-year discharges at Otis Company Dam. These values were computed by considering separately the controlled and uncontrolled portions of the watershed. Discharges from the uncontrolled areas were computed by averaging the results of regional discharge-frequency equations developed by Manual Benson (USGS, Water Supply Paper 1580-B) and by S. William Wandle, Jr. (USGS, Water Resources Investigations 77-39). Discharges from the controlled portion were estimated from the calculated release rates of the outlet structures from the SCS flood control dams in the watershed. The final discharges used were then the sum of discharges from the controlled and uncontrolled portions of the watershed. The FIS estimate for the 100-year flow rate is 1885 cfs.

Historic floods at the site have also been considered. The USGS estimated peak flow rate during the storm of March 1936 is 6160 cfs, while that for September 1938 is 4970 cfs. It should be noted, however, that since the time of these floods a number of flood control dams have been built on tributaries to the Souhegan River, including at least four upstream of the Otis Company Dam.

Considering the magnitude of the historic floods, an appropriately conservative Test Flood discharge of 5000 cfs was chosen.

The Test Flood of 5000 cfs is taken to be the value at the dam as modified by flow through the storage in the Otis Company Dam Pond. Although no direct storage routing is considered, a storage-stage curve is developed assuming that storage above the full dam level is equal to the lake area times the depth of surcharge. No spreading or increase of area with depth is considered.

The stage-discharge curve is developed by defining discharge as the sum of flow over the spillway, flow over the dam crest, and flow over the side slopes and side walls at the ends of the dam. The calculations determining these curves are documented in Appendix D.

The peak test discharge of 5000 cfs would result in a maximum stage of 6.2 feet above the spillway crest. This is 0.2 foot above the concrete wall at the right abutment and 1.5 feet above the ground surface at the left abutment. This would probably cause some street flooding in Greenville. The extent and depth of this street flooding, and the degree of hazard that it represents, has not been determined; though it should be similar to flooding which accompanied the 1936 event.

(f) Dam Failure Analysis

The peak outflow at Otis Dam No. 1 that would result from dam failure is estimated using the procedure suggested in the Corps of Engineers New England Division's April 1978 "Rule of Thumb Guidelines for Estimating Downstream Dam Failure Hydrographs." Failure is assumed to occur as soon as the dam crest is overtopped (El. 830.1). This is 4.7 feet above the spillway and some 19 feet above the tailwater at this discharge. It is assumed that a 28 foot gap is opened in the dam. The peak failure outflow through this gap and over the spillway would be 7000 cfs.

To determine if this flow would be a hazard to the bridge 170 feet downstream an estimate was made of the overflow capacity of the next dam downstream with a headwater at the level of the lower chord of the bridge. The estimated overflow capacity of 12,000 cfs is significantly greater than the dam failure flow of 7000 cfs, so the bridge should not be jeopardized by a failure of Otis Dam No. 1. However, the estimated flow depths of about 9 feet at the spillway of Dam No. 2 that would accompany a failure of Dam No. 1 might adversely affect the mill building abutting Dam No. 2, probably reaching the level of the lowest windows.

Dam No. 2 and Dam No. 3, about 500 feet further downstream are run-of-the-river spillway structures which could probably withstand the dam break flood wave without serious damage. Other structures along this first reach are located high enough above the river to escape damage. In particular, the second bridge about 1000 feet downstream of Otis Dam No. 1 has a high arch and would be unaffected.

The flood wave would be only slightly attenuated in the reach extending approximately 2200 feet downstream from the dam since the stream is confined to a steep, narrow channel with little available storage. It is assumed that the peak discharge at the end of this reach is still 7000 cfs.

Further downstream, where the banks are low and the channel slope milder, the channel capacity is only about 2000 cfs. The dam failure flow of 7000 cfs will clearly cause significant overbank flooding, particularly in low lying areas to the left. Some significant flooding to about a dozen homes on the right bank could also be expected. Based on estimated flow depths in a more confined section about 300 feet upstream, and considering that these flows will then be spread over the flood plain, flood depths of up to 1 foot above the sill level of these houses might be experienced. This could result in heavy economic losses, but would not be expected to endanger lives.

After these homes there are no structures for about another mile. Since the storage behind Otis Company dam is only 105 acre-feet and the flood plain along this reach is relatively extensive, the dam failure flood wave should be dampened out.

SECTION 6 - STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

(a) Visual Observations

The field investigation revealed no significant displacement or distress that would warrant the preparation of structural stability calculations based on assumed section properties and engineering factors.

The seals to the two inlet structures in the forebay and the seal for the sluice gate on the right upstream side are leaking and inoperable. The concrete on the spillway cap and both spillway abutments is spalled and eroded. The stones in the spillway structure need to be chinked.

(b) Design and Construction Data

No plans or calculations of value to a stability assessment are available for this dam.

(c) Operating Records

The only operating record of significant for this dam is that the dam was overtopped in 1938 without experiencing major damage. It is not clear, however, that the dam is presently in comparable condition.

(d) Post Construction Changes

The flood of 1936 caused some damage to the dam which required that some remedial changes be made. These changes did not adversely affect the structural stability of the dam.

(e) Seismic Stability

The dam is located in Seismic Zone No. 2 and, in accordance with recommended Phase I guidelines, does not warrant seismic analysis.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

(a) Condition

Otis Company Dam No. 1 is in FAIR condition at the present time.

(b) Adequacy of Information

The lack of in-depth engineering data does not permit a definitive review. Therefore, the adequacy of the dam cannot be assessed from the standpoint of reviewing design and construction data. This assessment is based primarily on the visual inspection, past performance, and sound engineering judgment.

(c) Urgency

The recommendations and improvements contained herein should be implemented by the owner within one year of receipt of this phase I report.

(d) Need for Additional Investigations

Additional investigations should be performed by the owner as outlined in Paragraph 7.2 below.

7.2 Recommendations

It is recommended that a registered professional engineer be engaged by the owner to do the following:

- 1) Perform an engineering investigation of the fore-bay inlets to the old mill building.
- 2) Perform an engineering investigation of the sluice gate on the right upstream training wall.

The findings of these investigations should be implemented by the owner.

7.3 Remedial Measures

It is recommended that the following remedial measures be undertaken by the owner:

- 1) Monitor the seepage at the left spillway end wall at its interface with the bedrock. In particular, Note any changes in the quantity or turbidity of the flow.
- 2) Check the voids in the downstream face of the spillway.
- 3) Develop a formal written flood emergency warning system to alert downstream people.
- 4) Institute a program of annual technical inspections of the dam.
- 5) Monitor the settlement of the left upstream end wall.
- 6) Repair the base of the left concrete spillway end wall, the concrete cap on the spillway and the base of the right spillway end wall.

7.4 Alternatives

One possible alternative would be to breach the dam. The legal ramifications of this step would have to be studied.

APPENDIX A
VISUAL INSPECTION CHECKLIST

INSPECTION TEAM ORGANIZATION

Date: November 14, 1978

NH 00041
OTIS COMPANY DAM NO. 1
Greenville, New Hampshire
Souhegan River
NHWRB 101.01

Weather: Overcast 50°F ±

INSPECTION TEAM

Nicholas Campagna	Goldberg, Zoino, Dunnicliff & Associates, Inc. (GZD)	Team Captain
Robert Minutoli	GZD	Geotechnical
Andrew Christo	Andrew Christo Engineers, Inc. (ACE)	Structural
Paul Razgha	ACE	Concrete
Richard Laramie	Resource Analysis, Inc.	Hydrology

The inspection team was accompanied by Mr. Pattu Kesavan of the New Hampshire Resources Board and the caretaker for the Otis Company mill building.

CHECK LISTS FOR VISUAL INSPECTION		
AREA EVALUATED	BY	CONDITION & REMARKS
DAM SUPERSTRUCTURE		
A. General		
Vertical alignment and movement	AC	No deficiencies noted
Horizontal alignment and movement		No deficiencies noted
B. Left Upstream End Wall		Settlement and displacement of face stones
C. Left Spillway Abutment Structure		
Stone masonry		Mortared joints eroded
Seepage		Low rate over entire interface with bedrock (less than 1 gpm)
Downstream concrete extension		
Condition of concrete		Poor
Spalling		See erosion
Erosion		At base 4' high x 2' wide x 12" deep
Cracking		None noted
Rusting or staining of concrete		None noted
Visible reinforcing		None noted
Efflorescence		None noted
Seepage		Through eroded area at the rate of 2 gpm
Vegetation	AC	Six inch diam. tree stump at top of concrete

CHECK LISTS FOR VISUAL INSPECTION

AREA EVALUATED	BY	CONDITION & REMARKS
Pipe outlet	AC	Butterfly valve permanently sealed
D. Right Abutment Structure		
Condition of concrete		Fair
Spalling		See erosion
Erosion		Base of structure adjacent to spillway eroded over 10' long x 2" high by 12" deep. Interface with spillway crest eroded 2"
Cracking		None noted
Rusting or staining of concrete		None noted
Visible reinforcing		None noted
Efflorescence		None noted
Seepage		None noted
E. Right Upstream Training Walls		
Stone masonry walls		No evidence of displaced stones, bulging or signs of distress
Concrete foundation wall	AC	Fifty percent of vertical face honeycombed. Erosion adjacent to sluice gate 3' long, 6" high and 6" deep

CHECK LISTS FOR VISUAL INSPECTION		
AREA EVALUATED	BY	CONDITION & REMARKS
<p>F. Downstream Training Walls</p> <p>Left bank</p> <p>Cemented stone masonry wall between abutment and building foundation</p> <p>Building foundation wall</p> <p>Lower dry stone masonry wall</p> <p>Concrete tailrace outlet</p> <p>Downstream concrete training wall</p>	<p>PR</p> <p>PR</p>	<p>Good condition without any evidence of eroded joints, displaced stones, bulging or other signs of distress</p> <p>Good condition without any evidence of eroded joints, displaced stones or other signs of distress. One third of buttress mortared joints effloresced</p> <p>Good condition without any evidence of displaced stones, bulging or other signs of distress</p> <p>Poor condition. Top and vertical faces spalled over 50% of their faces. Base of side-walls eroded from channel bed 3' high. Timber flap gate completely destroyed</p> <p>Honeycombed over 50% of its vertical face. No evidence of spalls, cracks or efflorescence</p>

CHECK LISTS FOR VISUAL INSPECTION

AREA EVALUATED	BY	CONDITION & REMARKS
Right bank		
Splayed walls	PR	Good condition without any evidence of displaced stones, bulging or other signs of distress
Training wall		Good condition without any evidence of displaced stones, bulging or other signs of distress. Water discharging through three outlets at base of wall. Wood picket fence in fair condition
G. Building	PR	Structure is in good condition with exception of timber plank floor in basement which is partially rotted. The housed power generating equipment is no longer operable
OUTLET WORKS		
A. Spillway		
Condition of concrete cap	AC	Very poor
Spalling		See erosion
Erosion		Eroded over its entire top and downstream face. Downstream face eroded 8' long 18" high and 18" deep adjacent to right abutment. Top eroded 3' x 3' x 2" deep adjacent to right abutment
Cracking	AC	None noted

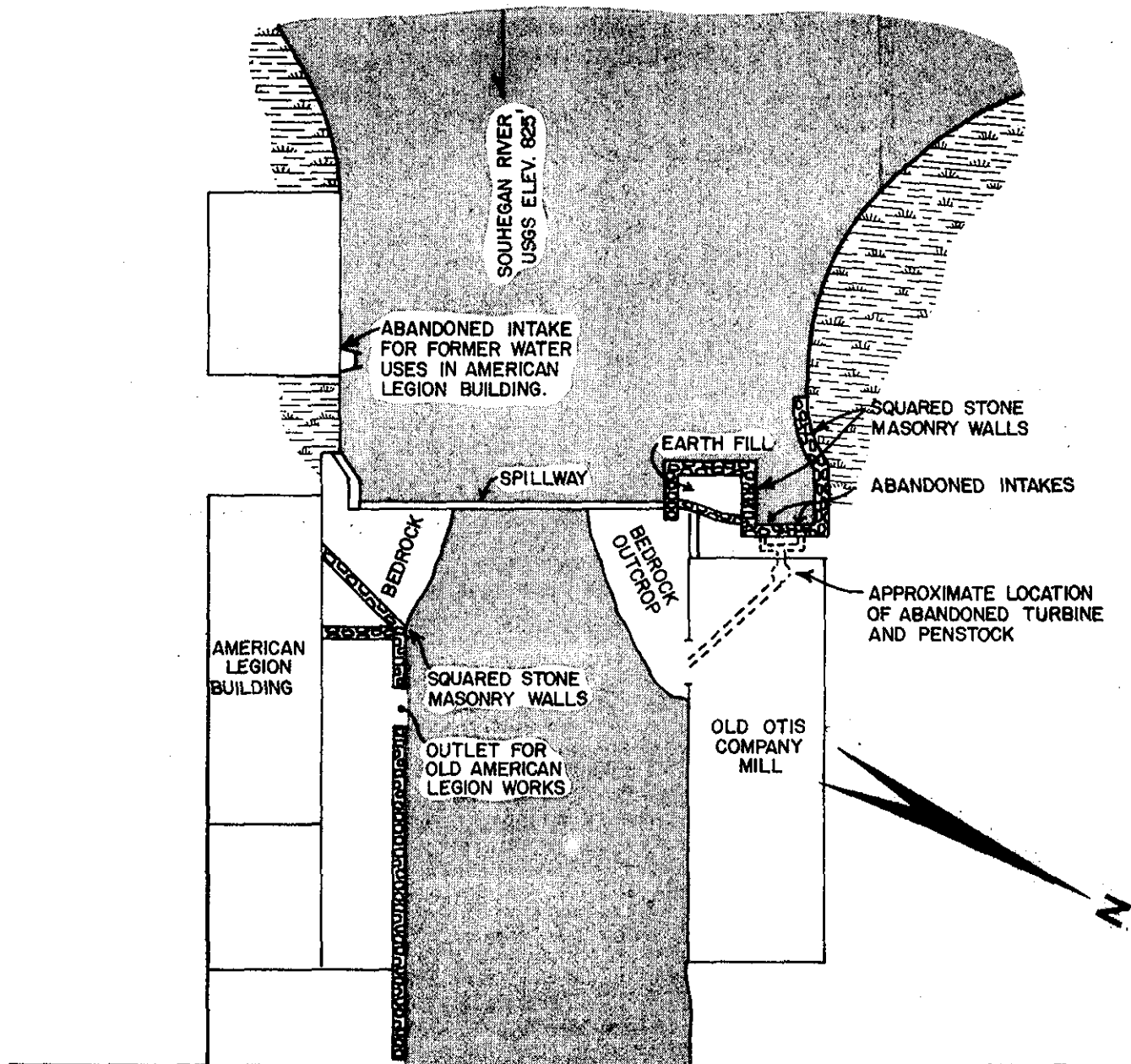
CHECK LISTS FOR VISUAL INSPECTION		
AREA EVALUATED	BY	CONDITION & REMARKS
Rusting or staining of concrete	AC	None noted
Visible reinforcing		None noted
Efflorescence		None noted
Seepage		None noted
Condition of stone masonry	AC	Chinking stones displaced from joints. Minor stone displacement at base of structure adjacent to left abutment No seepage observed
B. Forebay	PR	Right wall partially unravelled and tilting outward. Wall is undermined. Timber service platform framing rotted at numerous locations. Minor rot on timber trash rack. Steel trash rack heavily corroded
Sluice gates		Inoperable
C. Right Upstream Gate	PR	Concrete in poor condition. Erosion at crest level and spalling on its vertical faces
Sluice gate structure		Inoperable. Timber stem rotted. Seepage through gate. Wooden trash rack partially rotted.
Sluice gate		
RESERVOIR		
A. Shoreline		
Evidence of slides	NAC	None noted
Potential for slides	NAC	Shoreline stable

CHECK LISTS FOR VISUAL INSPECTION

AREA EVALUATED	BY	CONDITION & REMARKS
B. Sedimentation	NAC	None visible
C. Upstream hazard areas in the event of back- flooding		None noted
D. Changes in nature of watershed		None noted
DOWNSTREAM CHANNEL		
A. Trees overhanging channel		None noted
B. Bottom conditions		No obstructions noted
OPERATION AND MAINTENANCE FEATURES		
A. Reservoir Regulation Plan		None exists
B. Maintenance	NAC	Situation indicates a more rigorous program needed

APPENDIX B

		<u>Page</u>
FIGURE 1	Site Plan	B-2
FIGURE 2	Plan of Dam and Elevation From Downstream	B-3
	List of Pertinent Data not Included on Their Location	B-4



ROUTE 31 (BRIDGE OVER SOUHEGAN RIVER IN GREENVILLE, N.H.)

GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC.
GEOTECHNICAL CONSULTANTS
NEWTON UPPER FALLS, MASS.

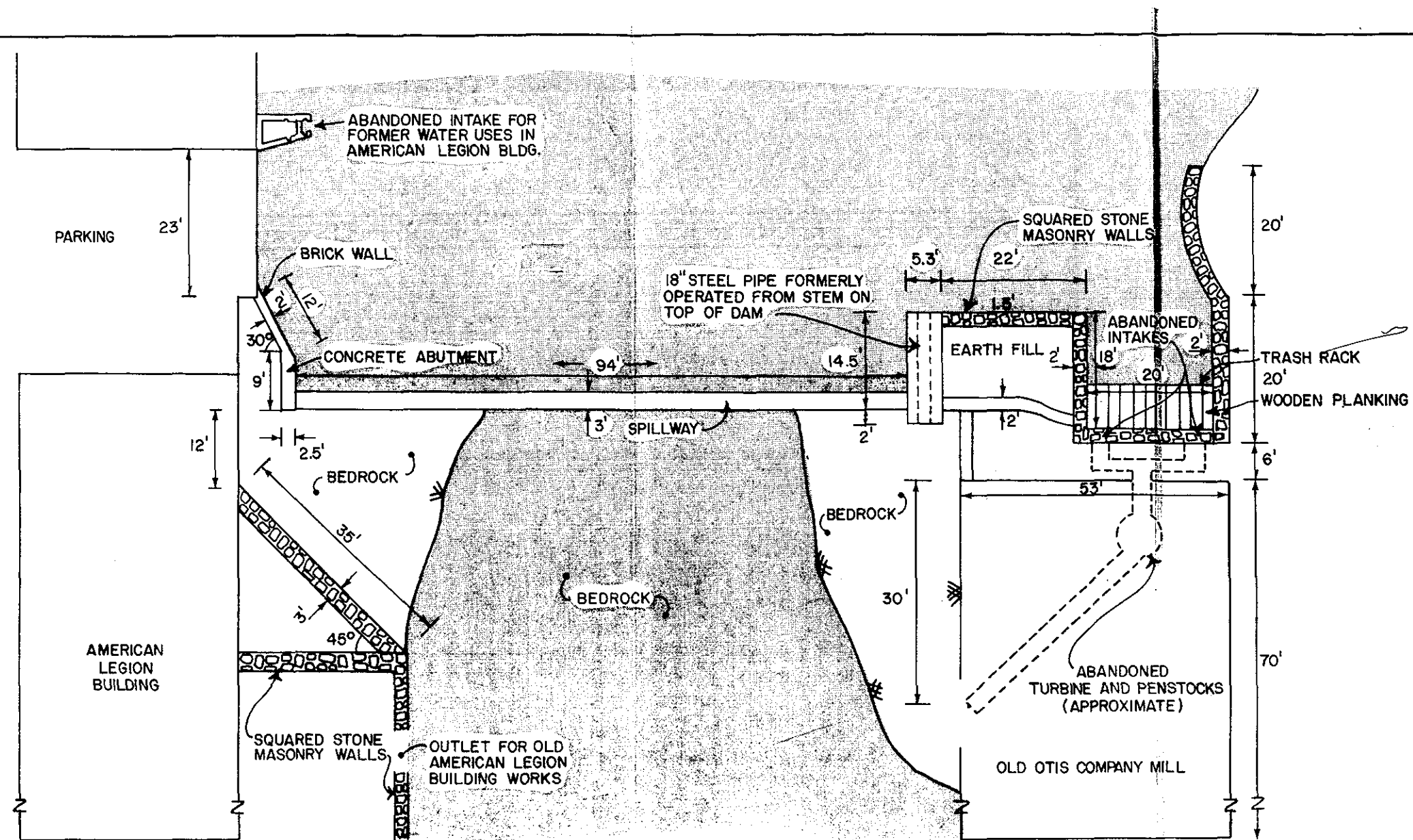
U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

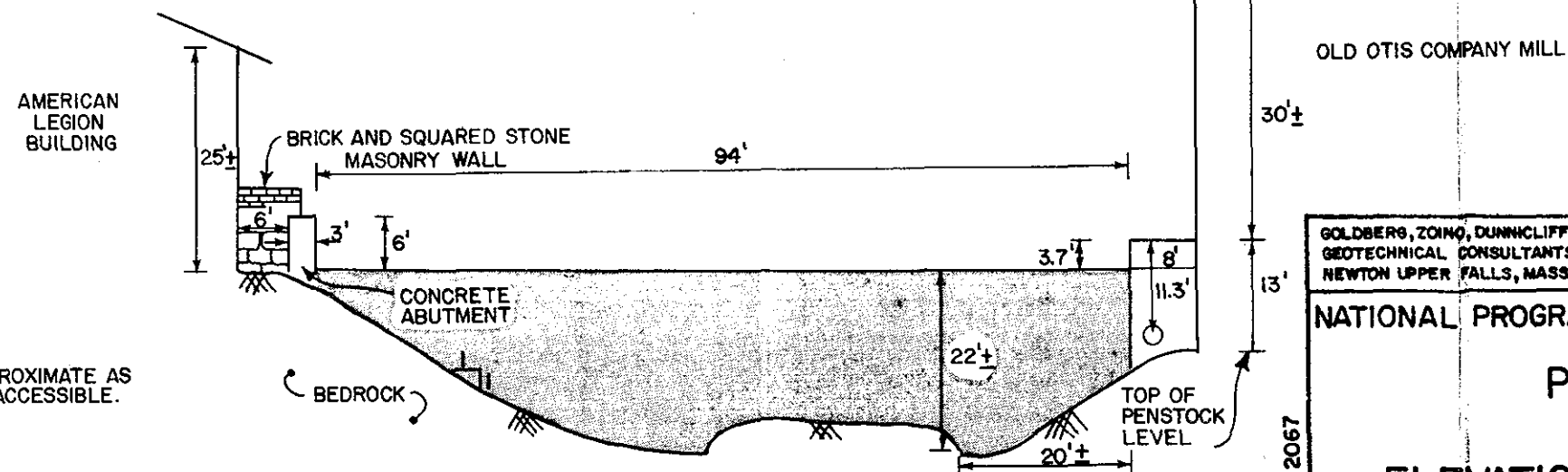
SITE PLAN

OTIS CO. DAM No. 1

SCALE 1" = 50'
DATE NOVEMBER 1978



PLAN OF DAM



ELEVATION FROM DOWNSTREAM

NOTE:
SOME DIMENSIONS APPROXIMATE AS
ALL FEATURES NOT ACCESSIBLE.

GOLDBERG, ZIMMO, DUNNCLIFF & ASSOC., INC. U.S. ARMY ENGINEER DIV NEW ENGLAND
GEOTECHNICAL CONSULTANTS CORPS OF ENGINEERS
NEWTON UPPER FALLS, MASS. WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS
FIGURE 2
PLAN OF DAM
AND
ELEVATION FROM DOWNSTREAM

OTIS COMPANY DAM No. 1

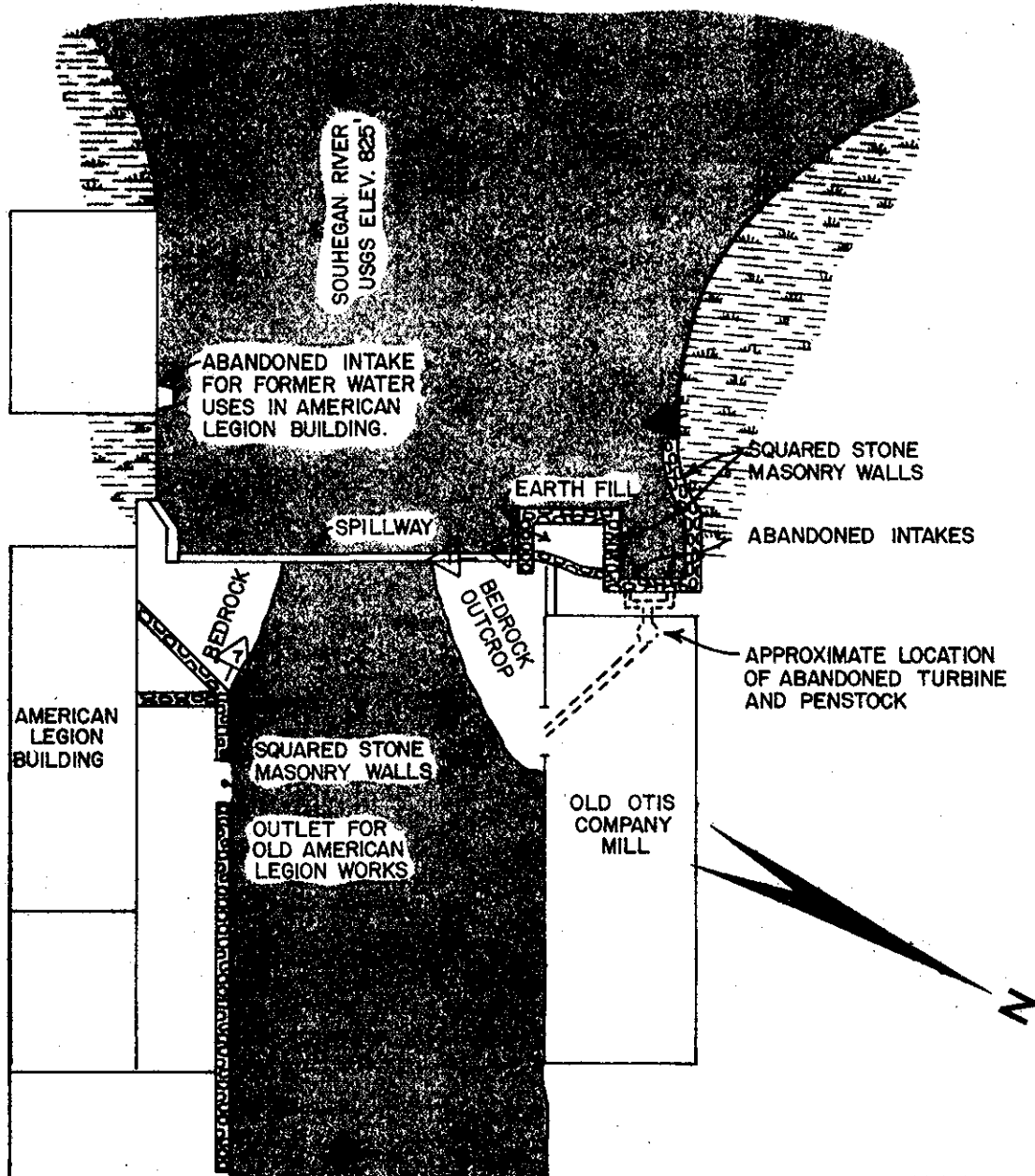
SCALE 1" = 20'
DATE NOVEMBER 1978

FILE No 2067

The New Hampshire Water Resources Board (NHWRB) located at 37 Pleasant Street, Concord, N.H. 03301 maintains a comprehensive correspondence file for the dam. Included in this file are the following items:

- (1) USGS "Report on Developed Water Power" dated May 27, 1920.
- (2) Several letters in 1936 regarding proposed repairs to the dam following the 1936 flood.
- (3) NHWRB "Inventory of Dams and Water Power Developments" dated October 29, 1937.
- (4) A New Hampshire Water Control Commission (NHWCC) Questionnaire on the maximum flood stage at the dam dated October 14, 1938.
- (5) NHWCC "Data on Dams in New Hampshire" dated December 6, 1938.
- (6) NHWCC "Data on Water Power Developments in New Hampshire" December 6, 1938.
- (7) NHWRB questionnaire on "Water Power Developments in New Hampshire" dated February 12, 1948.

APPENDIX C
SELECTED PHOTOGRAPHS



ROUTE 31 (BRIDGE OVER SOUHEGAN RIVER IN GREENVILLE, N.H.)

- ➡ OVERVIEW
- APPENDIX C

GOLDBERG, ZOINO, DUNNCLIFF & ASSOC., INC. GEOTECHNICAL CONSULTANTS NEWTON UPPER FALLS, MASS.		U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.	
NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS			
LOCATION AND ORIENTATION OF PHOTOS			
OTIS CO. DAM No. 1			
FILE No. 2201		SCALE 1" = 50'	
		DATE NOVEMBER 1978	



1. View from left side of spillway of bedrock outcrop forming right abutment



2. View from downstream channel showing bedrock under left side of spillway and abandoned waste gate



3. View from left end of spillway of concrete erosion at junction of spillway, right abutment, and right upstream training wall



4. View from top of dam of seepage at junction of mill building wall and left end of spillway



5. View of discharge channel outlet for old power works in mill building basement from right side of downstream channel



6. View from road bridge showing old mill dam just downstream of bridge



7. Deteriorated concrete cap of spillway
as viewed from the downstream right
side

APPENDIX D
HYDROLOGIC/HYDRAULIC COMPUTATIONS

I Dam Rating Curve

See page 2 for schematic sketch of overflow section based on 1937 NHWRB survey data, 1978 LeClair Assoc. survey data, and recent field inspection.

Q_2 and Q_3 represent flow overtopping a brick and a concrete wall running from the dam u/s along the right bank. Q_7 represents flow over a wall running along the front of the mill building, about 8' u/s

Datum -- spillway crest, elev. 825.4

$$Q_1 = 2.8 \times (H - 7.5) \times 10 \times (.5(H - 7.5))^{3/2}$$

$$Q_2 = 3.0 \times 40 \times (H - 7.5)^{3/2}$$

$$Q_3 = 3.0 \times 8 \times (H - 6.0)^{3/2}$$

$$Q_4 = 3.3 \times 93 \times H^{3/2}$$

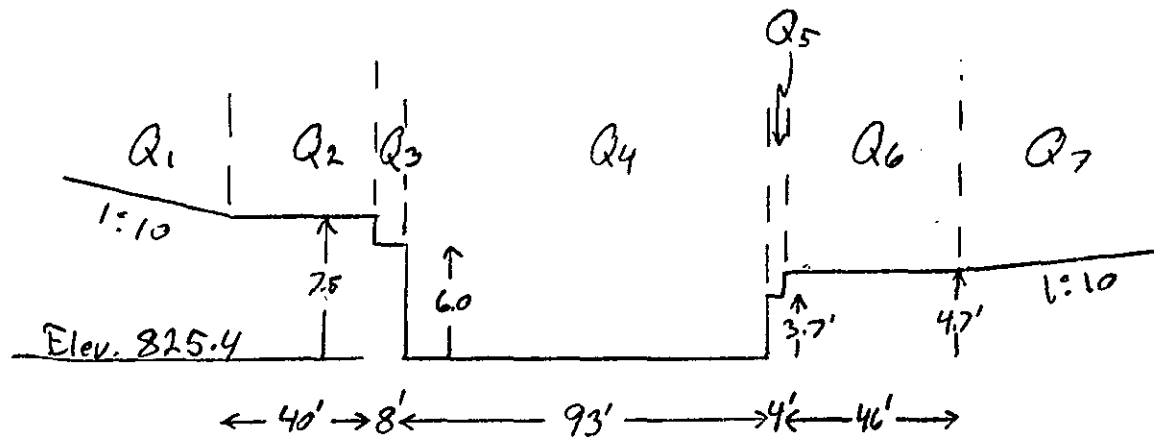
$$Q_5 = 3.0 \times 4 \times (H - 3.7)^{3/2}$$

$$Q_6 = 3.0 \times 46 \times (H - 4.7)^{3/2}$$

$$Q_6 = 2.8 \times (H - 4.7) \times 10 \times (.5(H - 4.7))^{3/2}$$

A BASIC program was written to calculate an aggregate stage-discharge function at the dam. A listing is shown on page 3, followed by tabulated output and a plotted curve.

D-3



Schematic Over-flow Section (looking upstream)

Otis Co. Dam #1

1.5 Lean Safety Otis Co. Dam 2-14-75 7/20

```

LIST
100 REM: STAGE DISCHARGE PROGRAM FOR OTIS COMPANY DAM # 1, JOB 165
110 REM: ON TAPE 10, FILE 57
120 PAGE
130 PRINT "DISCHARGE FROM OTIS COMPANY DAM # 1 AS A FUNCTION OF HEAD"
140 PRINT USING 150:
150 IMAGE // 2T"HEAD"30T"DISCHARGE"
160 PRINT USING 170:
170 IMAGE 1T"(FEET)"32T"(CFS)"
180 PRINT USING 190:
190 IMAGE 15T"TOTAL"8X"LEFT BANK"8X"RIGHT BANK"8X"SPILLWAY"
200 FOR H=0 TO 15 STEP 0.5
210 Q1=0
220 Q2=0
230 Q3=0
240 Q5=0
250 Q6=0
260 Q4=3.3*93*H↑1.5
270 IF H<=3.7 THEN 350
280 Q5=3*4*(H-3.7)↑1.5
290 IF H<=4.7 THEN 350
295 Q6=3*46*(H-4.7)↑1.5
300 Q7=2.8*(H-4.7)*10*(0.5*(H-4.7))↑1.5
320 IF H<=6 THEN 350
330 Q3=3*8*(H-6)↑1.5
340 IF H<=7.5 THEN 350
341 Q2=2.8*40*(H-7.5)↑1.5
342 Q1=2.8*10*(H-7.5)*(0.5*(H-7.5))↑1.5
350 T1=Q1+Q2+Q3
360 T2=Q5+Q6
370 T3=T2+Q4+T1
380 PRINT USING 390:H,T3,T1,T2,Q4
390 IMAGE 2T,2D.1D,14D,15D,18D,17D
400 NEXT H
410 END

```

DISCHARGE FROM OTIS COMPANY DAM # 1 AS A FUNCTION OF HEAD

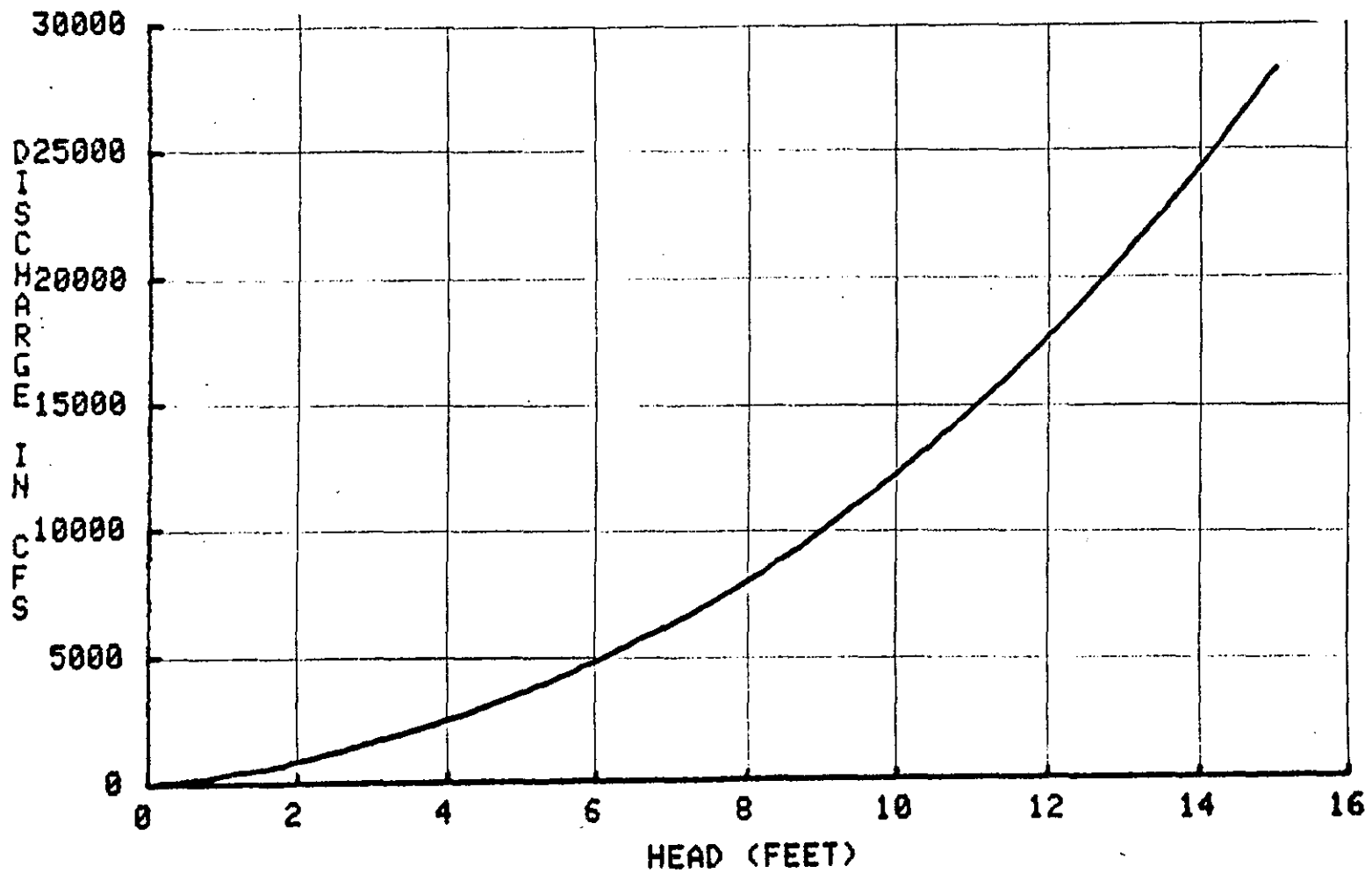
HEAD (FEET)	DISCHARGE (CFS)			
	TOTAL	BANK	BANK	SPILLWAY
0.0	0	0	0	0
0.5	109	0	0	109
1.0	307	0	0	307
1.5	564	0	0	564
2.0	868	0	0	868
2.5	1213	0	0	1213
3.0	1595	0	0	1595
3.5	2010	0	0	2010
4.0	2457	0	2	2455
4.5	2938	0	9	2930
5.0	3472	0	40	3431
5.5	4086	0	128	3959
6.0	4757	0	246	4510
6.5	5484	8	389	5086
7.0	6261	24	553	5684
7.5	7083	44	735	6304
8.0	7988	109	934	6944
8.5	8971	217	1148	7605
9.0	10021	358	1377	8286
9.5	11135	530	1619	8986
10.0	12311	733	1874	9705

D-5

4/20

STAGE-DISCHARGE CURVE AT OTIS COMPANY DAM # 1

D-6



5/25

II Dam Failure Analysis

Outflow at failure = Normal outflow at failure elev. + Outflow through breach

Assume that dam fails when the wall at the left abutment is overtopped -- elev. 830.1

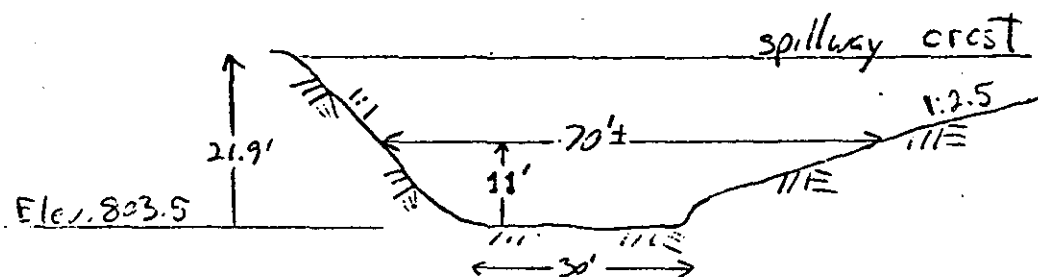
Normal Outflow

$$Q_{\text{normal}} = 3130 \text{ cfs}$$

Breach Outflow

$$Q_{p1} = \frac{8}{27} \times W_b \times \sqrt{g} Y_o^{3/2}$$

$$W_b \leq .4 \times (\text{Dam width at } 1/2 \text{ height})$$



$$\text{use } W_b = .4 \times 70 = 28'$$

$$Y_o = 830.1 - 811 = 19' \quad (\text{height from top of pool to tailwater @ failure -- tailwater elev. from FIS back water computation})$$

$$Q_{p1} = \frac{8'}{1.7} + 28 \times \sqrt{5} \times 19^{3/2} = 3900 \text{ cfs}$$

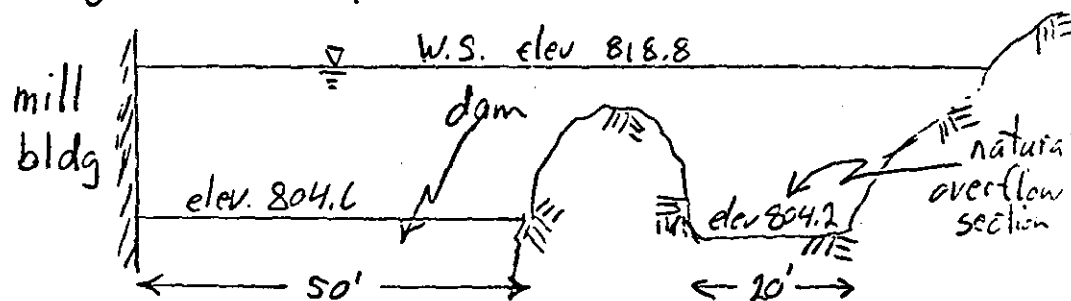
Total Outflow

$$Q_{tot} = 3900 + 3130 = 7030 \text{ cfs}$$

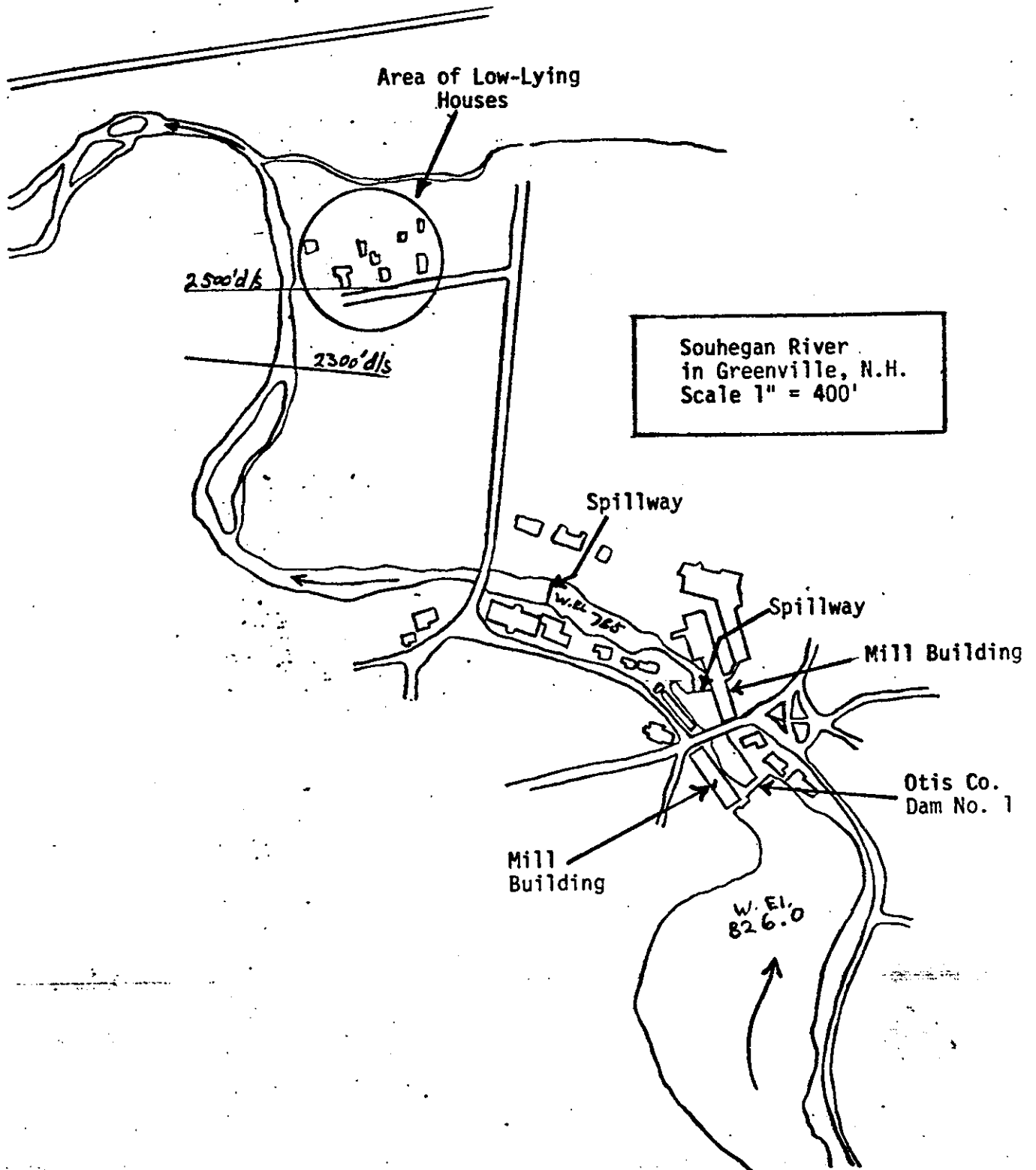
Downstream Flooding

A map of the reach of the Suhegan R. in Greenville d/s of the Otis Dam #1 is shown on page 8. This is copied from a map prepared in 1978 for an FIS study by ANCO.

Note that within 1000' d/s of the dam, the stream is crossed by two bridges and two small dams. Of particular interest is whether the backwater from the dam 300' d/s will affect the bridge 170' d/s.



Simplified section to dam #2 300' d/s
(looking ups)



Elev. of lower chord of bridge = 518.8

With the water surface at this elev., there is a head of 14.2' above the dam and 14.6' ± above the natural overflow section

Rough estimate of discharge w/ w.s. elev = 818.6

$$Q = 3.3 \times 50 \times 14.2^{3/2} + 3.0 \times 20 \times 14.6^{3/2}$$

$$= 12,200 \text{ cfs} > 7030 \text{ cfs } \underline{\underline{O.K.}}$$

Because the overflow capacity at dam #2 with the water surface at the bridge level is greater than the dam failure flow, the bridge shall not be damaged by a failure of Otis Dam #1.

The significant backwater depths above dam #2 (9' ±) that would accompany a failure of dam #1, might adversely affect the mill building which abuts dam #2. Flood depths could probably reach the level of the lowest windows (8' ± above dam #2 crest)

Dam #2 and dam #3, about 500' further d/s, are overflow structures which could probably withstand the dam break flood wave

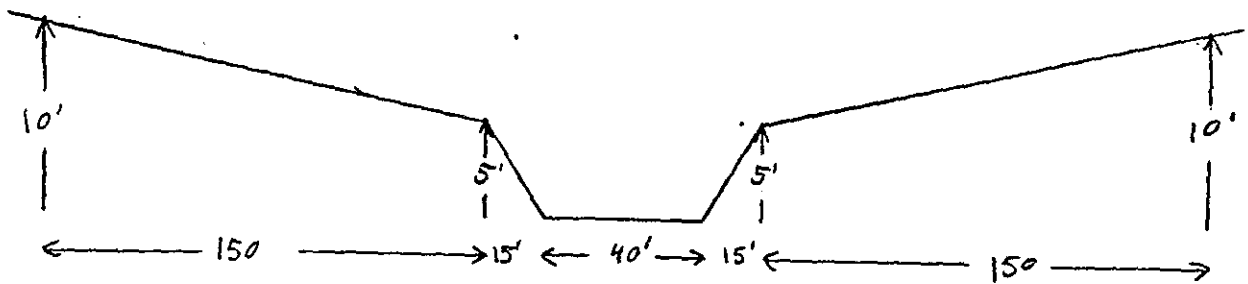
without serious damage.

The bridge approx. 1000' d/s of Otis Dam #1 has a high arch and would be unaffected by the dam break.

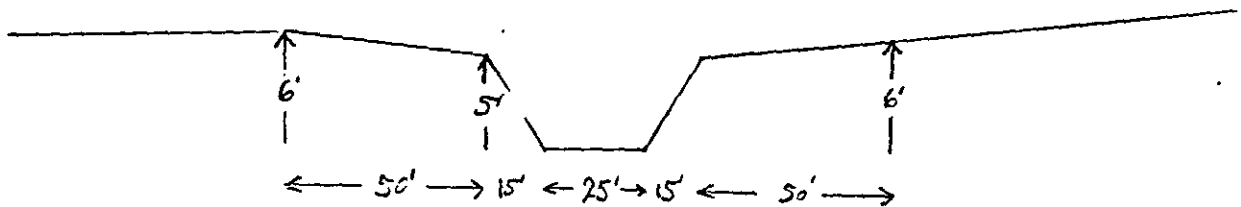
The reach of the Suckegon R. from Otis Dam #1 to a point about 2200' d/s is confined to a steep, narrow channel. The dam break flood wave would be attenuated but little along this reach for little storage is available. Assume the peak discharge at the end of the reach is still 7000 CFS.

The stream channel then becomes less confined allowing for fairly extensive overbank flooding at high flow rates. In this vicinity there are several houses ^{at the rt. bank} with ground floors approx. 6' above the stream bed.

Approx. channel X-sections 2300' -
d/s of Otis Dam #1, at transition, and
2500' d/s near the houses are shown on
the following page



Sauhegan R. Cross Section (approx.)
2300' d/s of Otis Dam



Sauhegan R. Cross Section (approx.)
2500' d/s of Otis Dam

Rating tables were computed, using a BASIC program, for the stream sections as sketched on the preceding page. The tables are shown on the following pages.

The dam failure discharge of 7000 cfs significantly exceeds the 2000 cfs channel capacity at the 2500' d/s x-section. Flooding will be greatest to the left where there are no structures, but some serious flooding of houses to the right could be expected. The ^{estimated} depth of flow in the more confined section (200' w/s) of 8 ft. indicates that ^{max.} flood depths of the houses will be less than $8 - 6 = \underline{2}$ ft. for the flow ^{will} spread over the flood plain, esp. to the left.

* Based on the rating table 2300' d/s of Otis dam w/ $Q = 7000$ cfs

D-14

DEPTH	ELEV	AREA	WPER	HYD-R	AR2/3	Q
0.0	740.0	0.0	0.0	0.0	0.0	0.0
0.5	740.5	20.8	43.2	0.5	12.7	58.1
1.0	741.0	43.0	46.3	0.9	40.9	186.7
1.5	741.5	66.8	49.5	1.3	81.5	371.8
2.0	742.0	92.0	52.6	1.7	133.5	609.0
2.5	742.5	118.8	55.8	2.1	196.5	896.4
3.0	743.0	147.0	59.0	2.5	270.3	1233.3
3.5	743.5	176.8	62.1	2.8	355.0	1619.4
4.0	744.0	208.0	65.3	3.2	450.5	2055.2
4.5	744.5	240.8	68.5	3.5	557.0	2541.0
5.0	745.0	275.0	71.6	3.8	674.6	3077.7
5.5	745.5	317.5	101.6	3.1	678.7	3096.5
6.0	746.0	375.0	131.7	2.8	753.8	3438.9
6.5	746.5	447.5	161.7	2.8	882.5	4026.1
7.0	747.0	535.0	191.7	2.8	1060.9	4840.0
7.5	747.5	637.5	221.7	2.9	1289.5	5883.1
8.0	748.0	755.0	251.7	3.0	1570.8	7166.3
8.5	748.5	887.5	281.7	3.2	1907.9	8704.0
9.0	749.0	1035.0	311.8	3.3	2304.3	10512.4
9.5	749.5	1197.5	341.8	3.5	2763.6	12608.2
10.0	750.0	1375.0	371.8	3.7	3289.7	15008.4

STREAM RATING

SOUHEGAN RIVER
2300 FT. D/S OF OTIS CO. DAM #1

6/

DEPTH	ELEV	AREA	WPER	HYD-R	AR2/3	Q
0.0	735.0	0.0	0.0	0.0	0.0	0.0
0.5	735.5	13.3	28.2	0.5	8.0	36.6
1.0	736.0	28.0	31.3	0.9	26.0	118.5
1.5	736.5	44.3	34.5	1.3	52.3	238.4
2.0	737.0	62.0	37.6	1.6	86.5	394.5
2.5	737.5	81.3	40.8	2.0	128.6	586.8
3.0	738.0	102.0	44.0	2.3	178.8	815.6
3.5	738.5	124.3	47.1	2.6	237.2	1082.0
4.0	739.0	148.0	50.3	2.9	304.0	1387.0
4.5	739.5	173.3	53.5	3.2	379.6	1731.6
5.0	740.0	200.0	56.6	3.5	464.1	2117.1
5.5	740.5	240.0	106.6	2.3	412.3	1881.0
6.0	741.0	305.0	156.6	1.9	475.7	2170.2

STREAM RATING

SOUHEGAN RIVER
2500 FT. D/S OF OTIS CO. DAM #1

Further downstream, there are no structures for about another mile. As storage behind Otis Co. dam is only 100 acre-ft., and as the flood plain ^{along this reach} is relatively extensive, the dam break flood wave should be enough damped out to present no additional hazard.

III Test Flood Analysis

Size classification = Small

storage < 1000 AF

height $< 40'$

Hazard classification -- Significant

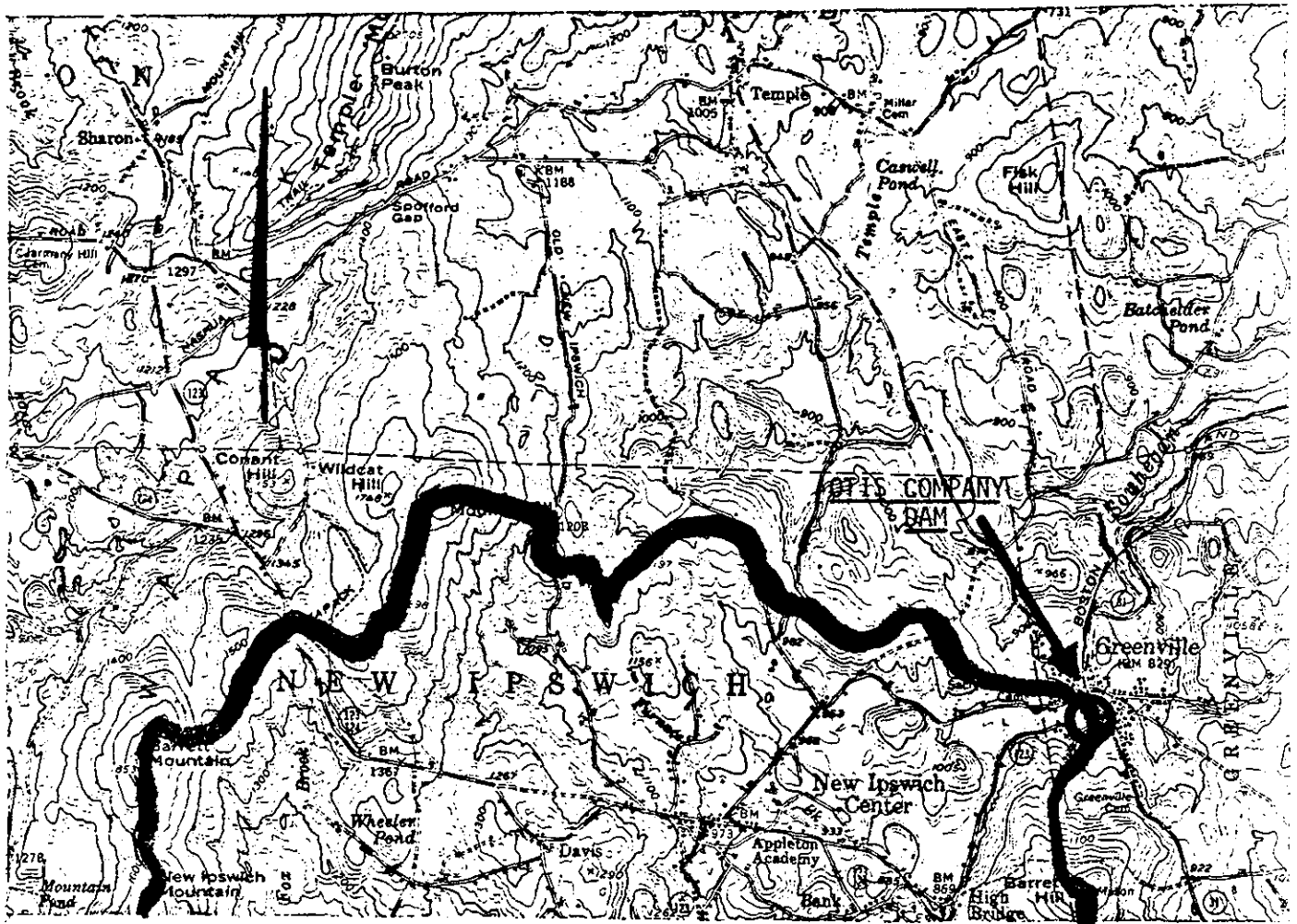
- serious flooding ($1' +$) to houses 2500' - 3000' d/s
- possible damage to mill building at rt. bank $\sim 300'$ d/s.
- no loss of life expected

Test Flood Selection

Per COE guidelines, a Small dam with Significant hazard potential should use 100 yr. to $\frac{1}{2}$ PMF Test flood. As the reservoir is particularly small (100 AF) and as no loss of life would be expected due to failure.

Choose a Test Flood of the order of the 100 yr. flood.

Drainage Area = 29.6 sq. mi (see map on next page)



Drainage Area Delineation (partial)
 Otis Company Dam No. 1
 Greenville, New Hampshire
 Drainage Area = 29.6 sq. mi.
 Scale 1:62,500

FIS Results

A 1978 study by ANCO estimated 10, 50, 100, and 500 year discharges at Greenville as follows

Recurrence Int.	Peak Discharge
10 years	955 cfs
50	1560
→ 100	1885 ←
500	3600

These were computed by summing discharges from controlled and uncontrolled portions of the watershed. The controlled discharges were estimated from release rates of outlet structures of SCS flood control dams in the watershed. The uncontrolled discharges were estimated by averaging the results of regional discharge-frequency equations developed by Manual Benson (USGS, WSP-1580-B) and by S. William Wandle, Jr. (USGS, WRI 77-39)

Historic Floods

March 1936

from USGS, WSP 798

Estimated Peak Discharge

$$Q = \underline{6160} \text{ cfs}$$

from NHWRB (see Inventory of Dams and
Water Power Developments)

$$* \begin{cases} H = 6.3' & (\text{high water level above crest}) \\ Q = \underline{6200} \text{ cfs} \end{cases}$$

September 1938

from USGS, WSP 867

Estimated Peak Discharge

$$Q = \underline{4970} \text{ cfs}$$

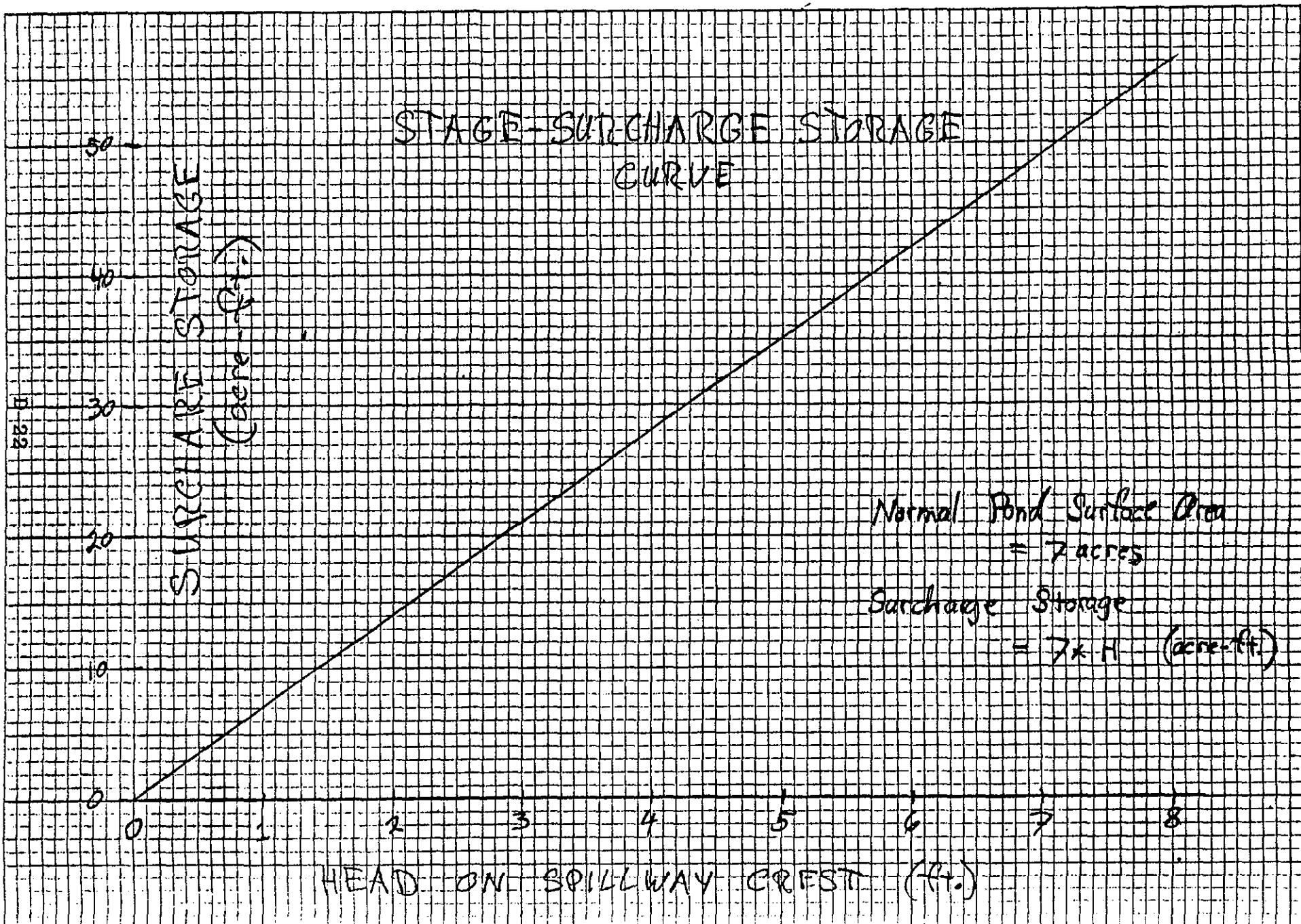
from NH Water Control Commission questionnaire

$$H \approx 5' \quad (\text{high water level above crest})$$

* The dam rating curve computed previously cannot be applied to this flood because the dam was reconstructed and the configuration changed after this flood.

Since the time of these floods, numerous flood control dams (at least 4) have been built by the SCS in the Suhegon R. watershed upstream of the Otis Co. Dam. However, considering the magnitude of these historic floods, a conservative Test Flood equal to 5000 cfs has been selected.

Taking this to be the value at the dam, do not consider storage routing through the reservoir. In any case, the surcharge storage available is too small to have much effect. A stage-discharge curve is shown on the following page.



Test Flood Summary

Size -- Small

Hazard -- Significant

Test Flood -- use 100 yr peak

 $Q_{100} = 5000 \text{ cfs}$ (F.I.S.)

Head = 6.2 ft (dam rating)

The ground surface at the left abutment will be flooded to a maximum depth of 1.5' under Test Flood conditions. The concrete wall at the right abutment would be overtopped to a depth of 0.2 feet

APPENDIX E
INFORMATION AS CONTAINED IN
THE NATIONAL INVENTORY OF DAMS



INVENTORY OF DAMS IN THE UNITED STATES

STATE	IDENTITY NUMBER	DIVISION	STATE	COUNTY	CONGR. DIST.	STATE	COUNTY	CONGR. DIST.	NAME	LATITUDE (NORTH)	LONGITUDE (WEST)	REPORT DATE DAY MO YR
NH	41	NED	NH	011	02				OTIS COMPANY DAM NO 1	4246.0	7148.7	16MAR79

POPULAR NAME	NAME OF IMPOUNDMENT

REGION	BASIN	RIVER OR STREAM	NEAREST DOWNSTREAM CITY-TOWN-VILLAGE	DIST FROM DAM (MI.)	POPULATION
01	05	SOUHEGAN RIVER	GREENVILLE	0	

TYPE OF DAM	YEAR COMPLETED	PURPOSES	STRUCTURAL HEIGHT (FT.)	HYDRAULIC HEIGHT (FT.)	IMPOUNDING CAPACITIES MAXIMUM (ACRE-FT.)	NORMAL (ACRE-FT.)	DIST	OWN	FED R	PRV/FED	SCS A	VER/DATE
GRCIPG	1936	0	27	27	105	75	NED	N	N	N	N	16MAR79

REMARKS
22-REPAIRED 23-NGNE

D/S HAS	SPILLWAY			MAXIMUM DISCHARGE (FT.)	VOLUME OF DAM (CY)	POWER CAPACITY		NAVIGATION LOCKS										
	CHEST LENGTH	TYPE	WIDTH (FT.)			INSTALLED (MW)	PROPOSED (MW)	NO.	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)				
2	150	U	94	3100														

OWNER	ENGINEERING BY	CONSTRUCTION BY
PIONEER PLASTICS		JOHN A STEPHENS INC

REGULATORY AGENCY			
DESIGN	CONSTRUCTION	OPERATION	MAINTENANCE
NH WATER RES BD	NH WATER RES BD	NH WATER RES BD	NH WATER RES BD

INSPECTION BY	INSPECTION DATE DAY MO YR	AUTHORITY FOR INSPECTION
GOLDBERG ZQINO DUNNICLIFF ASSOC	14NOV78	PUBLIC LAW 92-367

REMARKS
48-REPAIR IN 1936